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PRINCIPAL SOURCES AND DISPERSAL PATTERNS OF SUSPENDED PARTICULATE MATTER IN NEARSHORE SURFACE WATERS OF THE NORTHEAST PACIFIC OCEAN AND SEASONAL VARIATION IN SNOW COVER IN THE SIERRA NEVADA.

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20 August 1973

Type I Progress Report for Period 1 June - 15 August 1973

Prepared for:

Goddard Space Flight Center
Greenbelt, Maryland 20771

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Type I Progress Report

ERTS-1

a. PRINCIPAL SOURCES AND DISPERSAL PATTERNS OF SUSPENDED PARTICULATE MATTER IN NEARSHORE SURFACE WATERS OF THE NORTHEAST PACIFIC OCEAN AND SEASONAL VARIATIONS IN SNOW COVER IN THE SIERRA NEVADA.

b. GSFC ID No. of P. I.: IN 011 Subdisciplines: 4G, 5B

c. Statement and explanation of <u>any</u> problems that are impeding the progress of the investigation:

Clouds again obscured the principal test sites when attempts were made to obtain oceanographic data coincident with satellite passes.

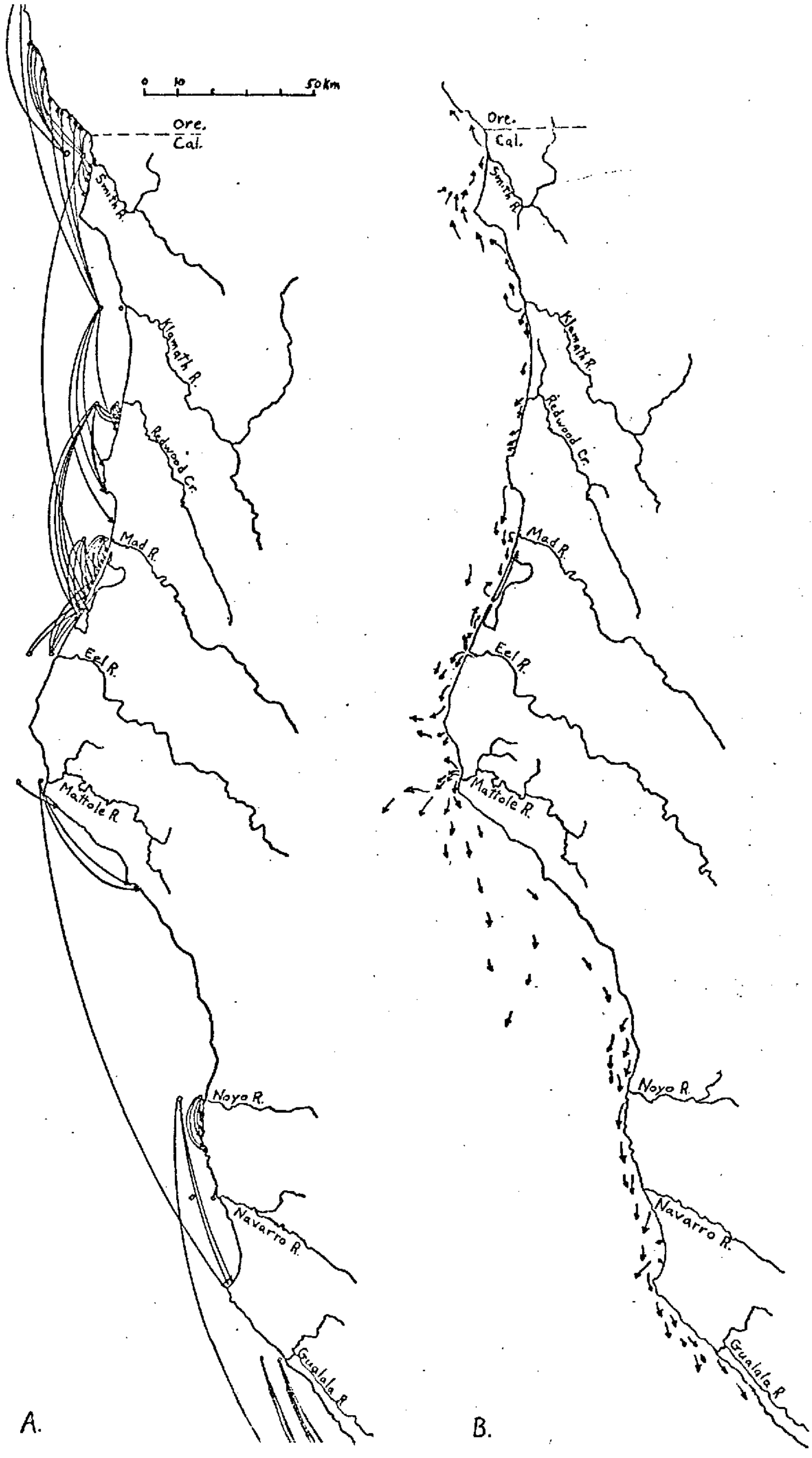
Sporadic receipt of imagery has posed some planning problems. The imagery for adjacent test sites does not arrive in chronological order, and we often are forced to delay sending the imagery to the photo lab for enhancement (a step necessary because of the very low contrast of water patterns). We are not sure whether the desired image was obtained, or was covered by more than 70% clouds. It would help us to know when the computer rejects an image because of excess cloud cover.

d. Discussion of the accomplishments during the reporting period and those planned for the next reporting period:

On June 14, 1973, two reconnaissance flights were made in preparation for the June 15-18 satellite passes over San Francisco Bay and the central and northern California coastal areas. A single-engine aircraft was flown at $\sim$2800 m (9500 ft) over San Francisco Bay and the adjacent ocean to observe and photograph patterns of suspended sediment, which are indicators of the circulation of near-surface water. These observations were used to plan a water-sampling cruise in San Francisco Bay coincident with the satellite pass of June 15. Measurements included salinity, percent light transmission, depth of Secchi disc visibility, and weight of suspended sediments. We have not received satellite imagery of that date and therefore are hampered in our attempt to correlate imagery and "water truth".

The second aircraft (twin engine) was used to drop drift cards off the mouths of rivers and streams between Pt. Sur (central California) and the Smith River (northern California). A total of 1900 cards in packs of 50 were dropped 1.6 and 8.1 km (1 and 5 mi.) seaward of the river mouths. These orange plastic cards had a weight in one corner and a styrofoam float in the opposite corner, which caused them to float almost totally submerged and thus be carried by and indicate the near-surface currents. As of August 14, 1973, 10 percent of the cards have been returned. A preliminary comparison of the current directions indicated by the drift cards with those suggested by the ERTS imagery of the northern California coast shows general agreement (Fig. 1). South of Cape Mendocino the currents flowed toward the south, but from the Cape to beyond the Oregon border, the pattern was more complex.

Figure 1. Near-surface nearshore current directions, mid-June 1973, along the northern California coast as indicated by drift cards (A) and ERTS satellite imagery (B). The arrows in panel A indicate the point of origin (small circles off rivers) and point of recovery (arrowheads impinging on coastline) of drift cards dropped on June 14, 1973, and reported by August 14, 1973. Current directions as represented by arrows in panel B were interpreted from configurations of suspended sediment plumes present on ERTS green band imagery of June 17, 1973 (no. 1329-18281, -18283, and -18290).


0
10
50 km
Ore.
Cal.
Smith R.
Klamath R.
Redwood Cr.
Mad R.
Eel R.
Mattole R.
Noyo R.
Navarro R.
Gualala R.
A.
B.

Both the ERTS imagery and the drift-card data suggest a zone of convergence just north of Humboldt bay whereas divergence is indicated off the Klamath and Smith Rivers. For example, drift cards dropped 8.1 km (5 mi.) offshore of the mouth of the Klamath River were found on the beaches up to 63 km (39 mi.) south and up to 100 km (62 mi.) north of the Klamath River. Drift cards dropped oceanward of the Smith River mouth were also found on beaches north and south of the river (Fig. 1A). However, there were more cards north than south, and those carried north were found up to 60 km (37 mi.) from the river, whereas all but one of those carried south were found within 15 km (9 mi.) of the river.

In the spring the predominant wind direction along the northern California Coast changes from northerly to southerly, and, according to Schwartzlose and Reid (1972), the coastal current changes direction and begins to move southward. As a result of the change in wind direction, upwelling becomes a dominant force in spring and early summer. As a result of the upwelling, complex swirls of water develop on the coastal side of the southward-flowing California Current (Sverdrup, Johnson, and Fleming, 1942). Perhaps the areas of divergence and convergence are related to the seasonal upwelling phenomenon. Coastal configuration, local effects of the wind, and subsequent drift-card data will be studied before any conclusive explanation of the coastal current patterns will be attempted. Another drift card "drop" has been planned for the week of August 27, 1973, in conjunction with ERTS coverage of the central and northern California coastal zone. Drift cards are to be released from the same points along the coast at 2-month intervals. Data obtained from these releases together with interpretations made from ERTS imagery, will provide a seasonal "picture" of the near-surface current system along the central and northern California coast. Also during the week of August 27, 1973, a water monitoring cruise is planned for the San Francisco Bay system. This cruise will extend from the southern end of San Francisco Bay to the Sacramento-San Joaquin Delta to the Golden Gate, thus providing water measurements over the entire estuary. Continuous measurements will be made of salinity, temperature, water turbidity, chlorophyll, and nutrients. Discrete samples will be collected and analyzed for concentration and particle size distribution of suspended particulate matter.

Schwartzlose, R. A. and Reid, J. L., 1972, Near-shore circulation in the California Current: Calif. Mar. Res. Comm., Cal COFI Rept. 16, p. 57-65.

Sverdrup, H. U., Johnson, M. W., and Fleming, R. H., 1942, The Oceans: Englewood Cliffs, N. J., Prentice-Hall, Inc., 1060 p.

Preliminary analyses of ERTS-1 imagery of the Sierra Nevada Mountains indicate that the snow line can be readily outlined on MSS band 5 (0.6-0.7 μm) imagery. Changes in snow elevation in the central Sierras and the White Mountains were observed on ERTS images for October 22, 1972 (1091-18062), January 20, 1973 (1181-18062), March 15, 1973 (1235-18070) and May 26, 1973 (1307-18064). On October 22, 1972, heavy snow covered the western Sierras at elevations above 3000 meters and light snow extended below 2500 m (Fig. 2). The elevation of the snow line was about 3000 m in the eastern Sierras and the eastern White Mountains and about 2500 m in the western White Mountains. Snow covered most of the frame on the January 20, 1973, image, except the western edge of the Sierras, where snow extended to below 1500 m (Fig. 3). On March 15, 1973, the snow line was between 1500 and 2000 m in both western and eastern Sierras (Fig. 4). In the White Mountains the snow line occurred at 2000-2500 m in the west and about 2000 m in the east. By May 26, 1973, the snow had retreated to 2500-3000 m in the Sierras and to above 3000 m in the White Mountains (Fig. 5).

Plans for further study of snow cover in the Sierras include extension of the study area both north and south. In addition, we hope to relate climatic data from available precipitation and snow depth stations within the area to the ERTS images in order to determine how relative snow depth can be detected by variations in tone and brightness. Additional information is needed about the effect of vegetation on the recognition of the snow line on the ERTS images. Also planned is a study to relate snow cover to spring runoff in selected drainage basins on both the east and west flanks of the Sierra Nevada Mountains.

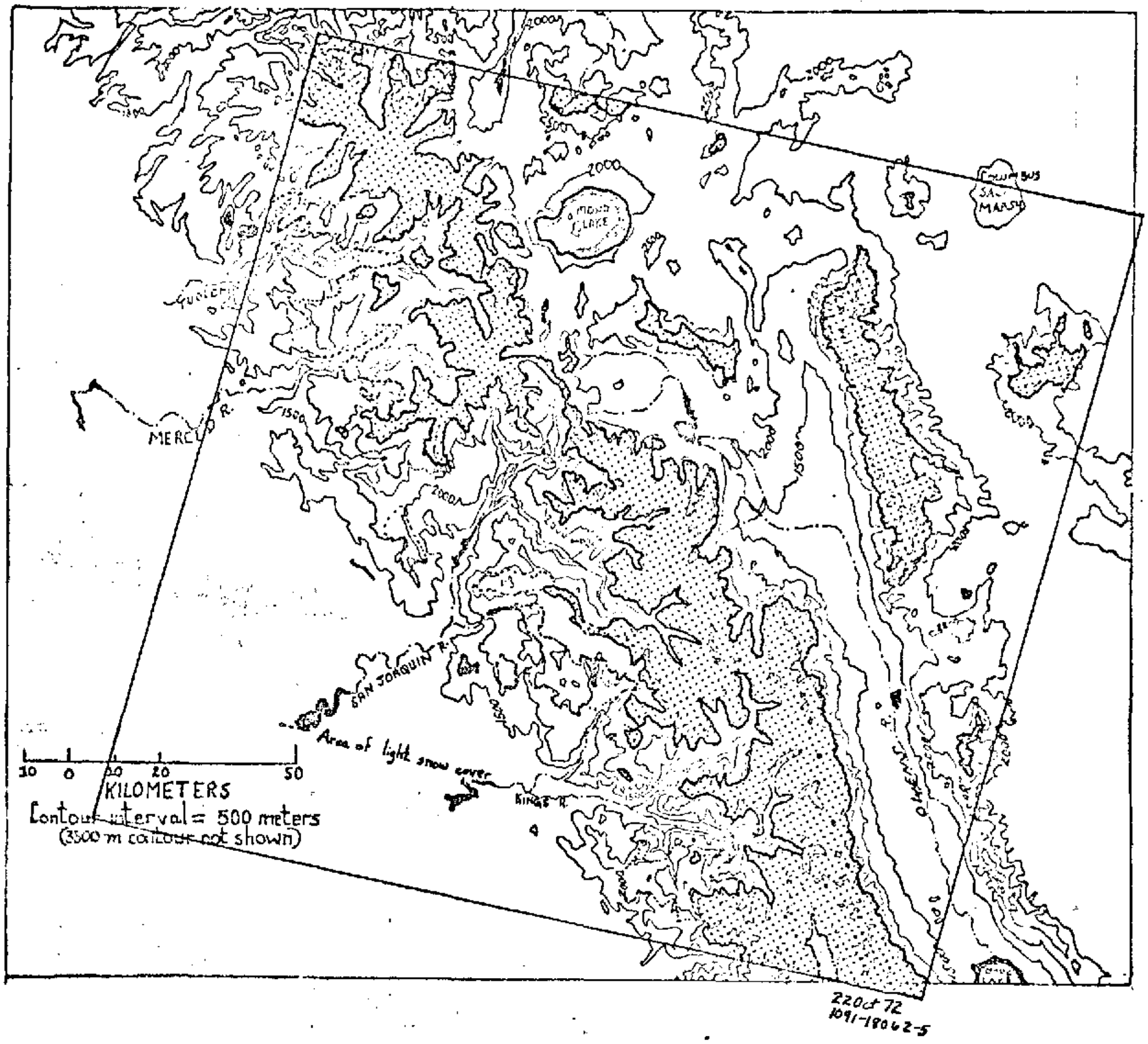


Figure 2. Snow line in the central Sierra Nevada Mountains on October 22, 1972. Stippled pattern is the snow-covered area recognizable on MSS-5 image 1091-18062. Base used in figures 2-5 was traced from the International Map of the World (1:1,000,000) U.S.G.S.

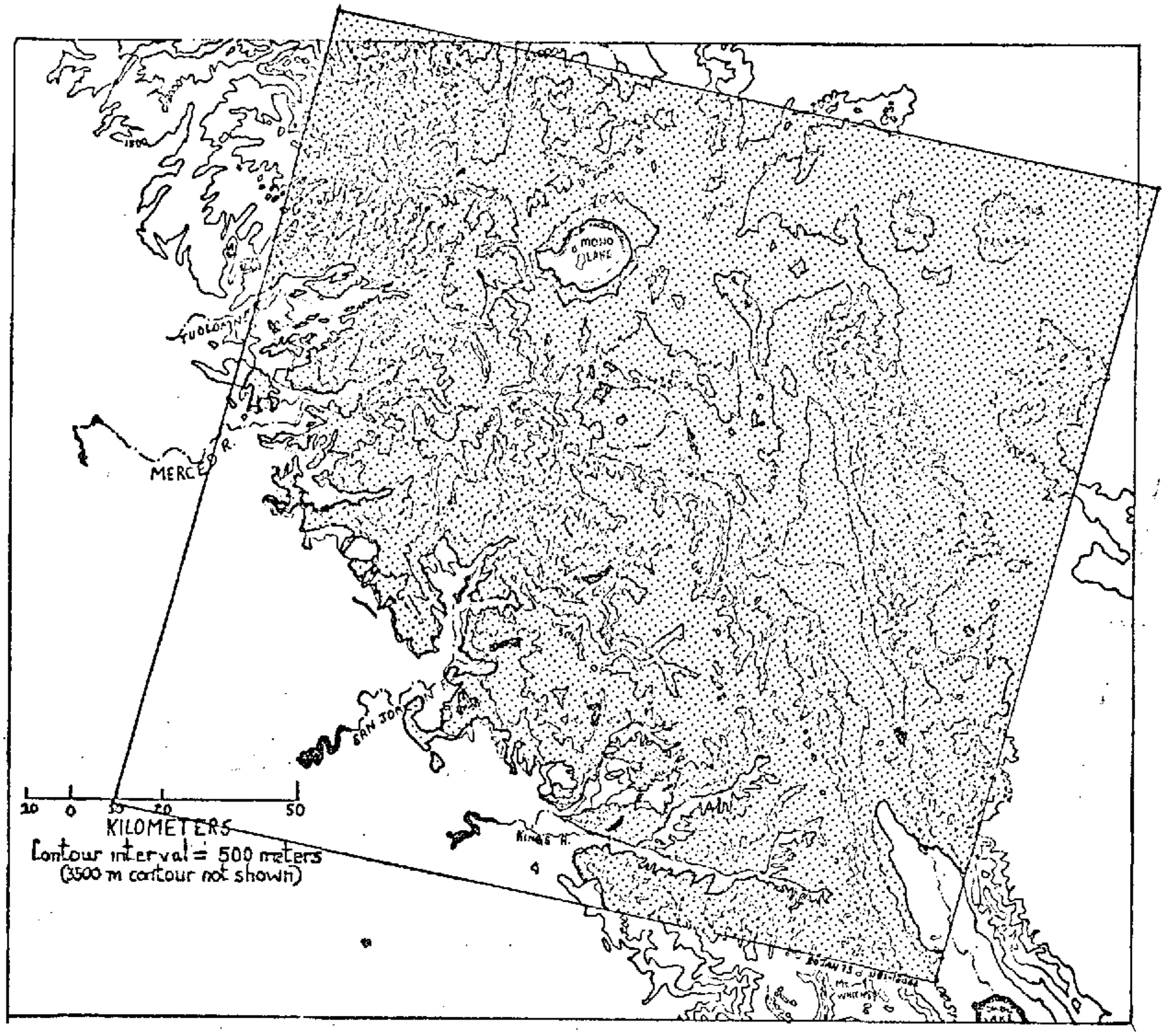


Figure 3. Snow line in the central Sierra Nevada Mountains on January 20, 1973. Stippled pattern is the snow-covered area recognizable on MSS-5 image 1181-18062.

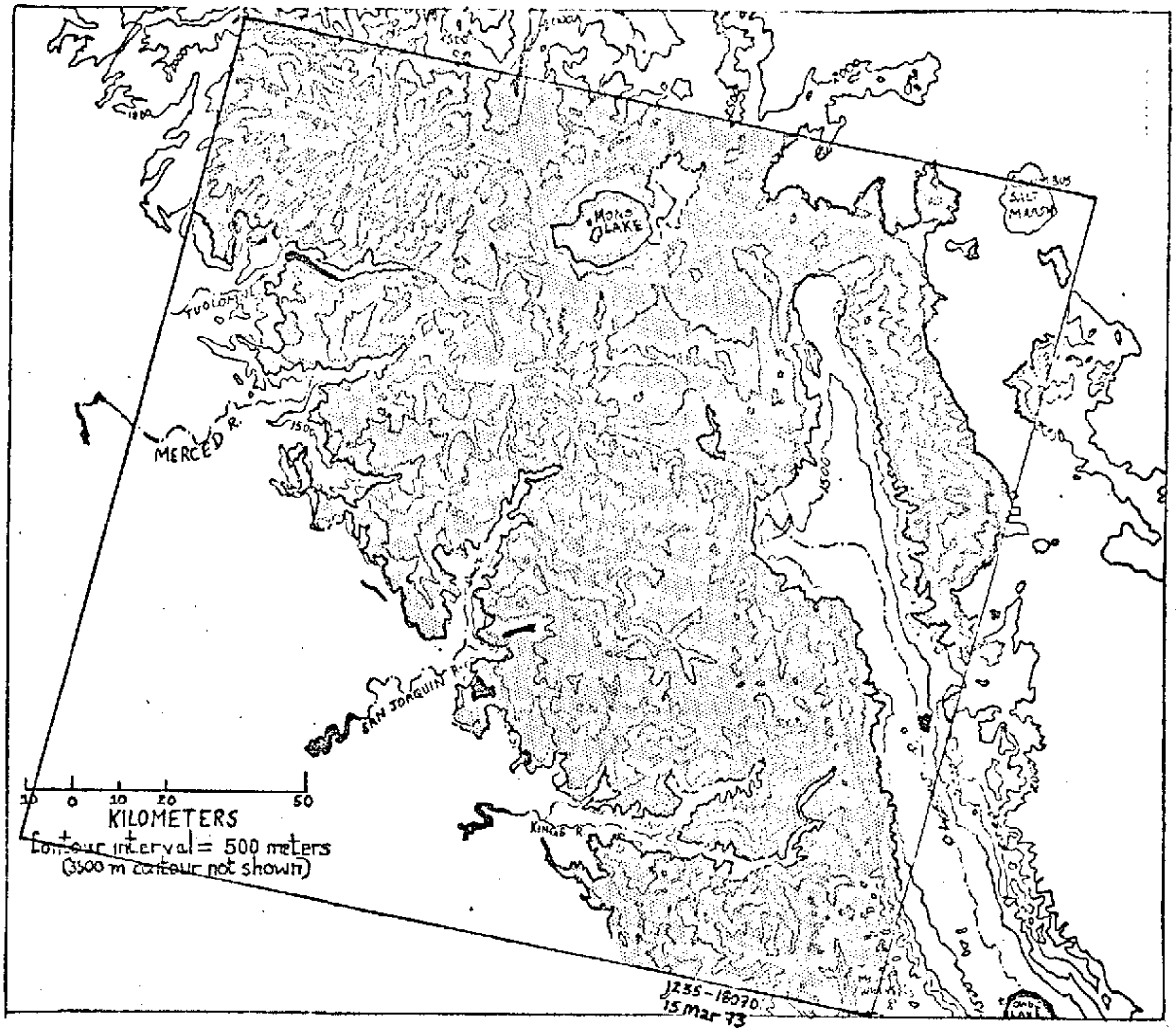


Figure 4. Snow line in the central Sierra Nevada Mountains on March 15, 1973. Stippled pattern is the snow-covered area recognizable on MSS-5 image 1235-18070.

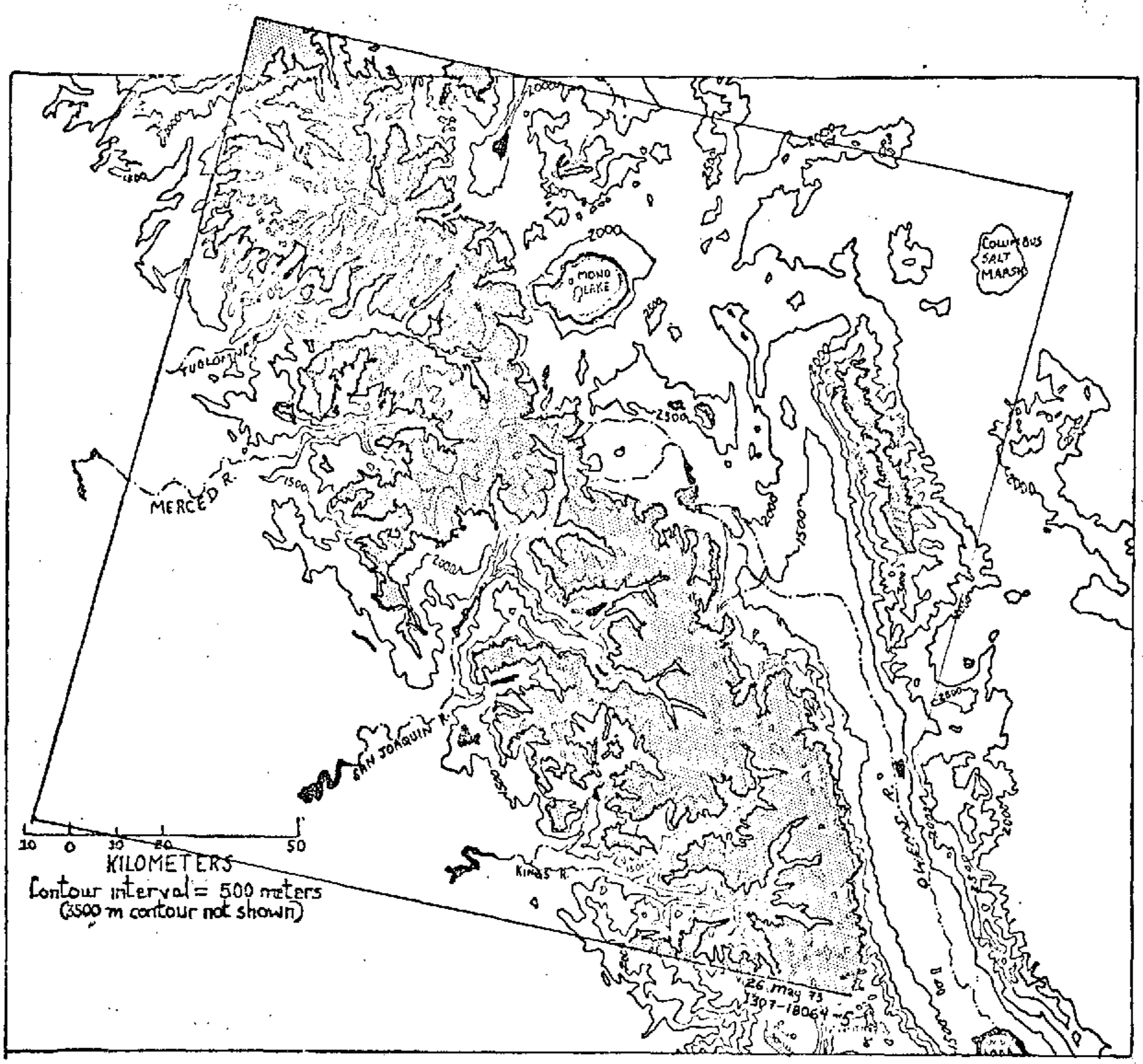


Figure 5. Snow line in the central Sierra Nevada Mountains on May 26, 1973. Stippled pattern is the snow-covered area recognizable on MSS-5 image 1307-18064.

e. Discussion of significant scientific results and their relationship to practical applications or operational problems.

ERTS imagery used in conjunction with surface-drift cards indicated a southerly flow direction of the central California near-surface coastal currents during mid-June 1973. The near-surface currents off northern California and southern Oregon were more complex. Some drift cards were recovered north and some south of their release points; however, the prevalent direction of flow was northerly. General agreement in flow direction of coastal currents obtained from ERTS imagery and drift card data reinforces the image interpretation. Complete seasonal coverage of nearshore circulation interpreted from ERTS imagery will provide information necessary for proper coastal zone management.

Extent of snow cover can be readily delimited on ERTS band 5. In the central Sierra Nevada Mountains this past winter season, the snow line, as recorded by ERTS, reached an elevation of less than 1500 meters in January but had melted back to between 2500 and 3000 meters by the end of May. ERTS imagery seems to provide sufficient resolution to make it a useful tool for monitoring changes in snow cover in the Sierra Nevada Mountains.

f. A listing of published articles, and/or papers, pre-prints, in-house reports, abstracts of talks, that were released during the reporting period:

Carlson, Paul., Janda, Richard, and Conomos, T. John, 1973, Observations of suspended particle patterns in nearshore northeastern Pacific Ocean waters by ERTS-1 imagery: Symposium on Significant Results Obtained from the Earth Resources Technology Satellite-1, NASA/ Goddard, v. 1, p. 1305.

g. Recommendation concerning practical changes in operations, additional investigative effort, correlation of effort and/or results as related to a maximum utilization of the ERTS system: NONE.

h. A listing by date of any changes in Standing Order Forms: NONE.

i. ERTS Image Descriptor forms: NONE.

j. Listing by date of any changed Data Request forms submitted to Goddard Space Flight Center/NDPF during the reporting period: NONE.

k. Status of Data Collection Platforms (if applicable): N/A.